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Original Research Article

Online Framework based on Serious Games for Healthcare:Case Studies

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Abstract: Integrating serious games for Health has been proposed through a unified framework expanding current Health informatics. Healthcare from this perspective includes care for persons with physical, mental or developmental limitations. The main objective is to suggest an online framework to configure, monitor and analyze the results of health intervention therapy based games using different media. The technology offers various possibilities to interact with the game through tools such as iPad, Kinect, Wii or robots. All of them communicated through internet and the information stored in the cloud. Having all the data in the cloud allows, not only have the updated tracking of the patient, also to update the treatment based on the combination of appropriate games for every stage of the disease. To do this, biofeedback information is included. The main benefit remains to be that Games can provide an improved lifestyle and a more friendly approach to health diagnostics and therapies when possible.
Keywords: Serious Games, therapeutic games, health information systems, evaluation, Human computer interfaces, social services.

INTRODUCTION

From an information technology perspective, we observe two emerging areas that contribute to health, e-health or m-health. The two areas of interest are health information systems and games. Health information systems are benefiting from advances in storage (mainly cloud computing), databases, and networks making it possible to exchange and access patient data by multiple providers and from multiple locations. Most of the effort is driven by insurance providers and government agencies in order to coordinate benefits and reduce cost. A major assumption is that such integration of health records will contribute to improved patient outcomes.

On another front, the widespread usage of computer games has also penetrated the e-m-Health area. With serious games used for education and training, they became a natural venue for patient education and evolved to applications of therapy and diagnostics. Usage of games in the health domain has also benefited from the increased popularity of mobile devices such as tablets and smart phones.

Health Information Systems

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Elements of a health information system typically include

- Patient basic information is the starting point for any health records and typically includes: Date of birth, height, weight, race, sex, initial health status.
- Diagnosis data such as Radiology images and sensor data such as Electrocardiogram (EKG) and Electroencephalogram (EEG).
- Recommended therapies such as medication and physical or occupational therapy.

We recommend inclusion of online games as part of the diagnosis and therapeutic data. That would also necessitate determination of game types, recording of patient utilization and scores. We extend the types of games to include physical objects including robots and game accessories.

We propose that games for e-m-Health be identified and categorized based on their roles and objectives. This allows healthcare professionals to recommend and use games in a standardized approach. A systemic approach for mapping games into various categories is certainly needed, but is beyond the scope of this paper. However, a review of existing efforts shows that the following objectives are driving development of different games:

- Healthy life style – games that promote a healthy life style by including physical exercise, caloric count and other factors are within this category.
- eDiagnosis – some games are used to diagnose patient condition based on response to visual or cognitive cues.
- eTreatment (therapy) – targeting specific conditions such as dyslexia or dementia some game designers work with therapists to induce therapeutic actions.
- eRehabilitation – this include physical, occupational and behavioral therapies.
- Entertainment – this is the main purpose of games and some are only focused on entertainment and we view them as a worthwhile category despite their lack of immediate health goals as they contribute to self-satisfaction and to social interaction as in the case of multi-user games.
- Edutainment – this category is the immediate off-spring of serious games as entertainment is weaved into patient education goals and success requires the user to achieve some learning outcomes.

Background

In this section, the different hardware tools which can be used and the assessment techniques are described.

Game technologies

There is a tendency towards gamifying therapies so as to enrich the users experience and become an appealing alternative capable of competing with present-day video games.

Many people find computer games difficult to control and those that suffer from tremor have difficulty in making accurate movements with their devices[1]. The study by Standen et al.[2] found difficulties with those devices that had to be positioned on a surface in order to be used, as is the case with most computer mice or keyboards. Also later results 3 confirmed that with problems like these, users might become frustrated and demotivated and fail to benefit from the advantages of using them.

This section gives an overview of alternative solutions to this mice and keyboard classical computerized therapies using different state of the art platforms: Consoles like Kinect and Wii, tactile interfaces and therapeutic robotics.

Kinect and Wii, a review of therapies using consoles

Virtual reality and motion-based games have been used for rehabilitation [35]. However, virtual reality requires wearing a number of sensors on the body, causing discomfort. This study developed a Kinect –based system to assist therapists in rehabilitating elderly. The proposed system uses Kinect sensors to detect elderly's movements and determine whether their movements are correct. The system also includes an interactive interface to enhance their motivation, interest, and perseverance with rehabilitation. Details of users' rehabilitation conditions are also automatically recorded in the system, allowing therapists to review rehabilitation progress quickly.

Video games have long been recognized to have useful purposes beyond entertainment. This is the case of the Serious Games which can be defined as games that engage the player while contributing to the achievement of a pre-defined objective [6]. Serious games usually refer to games that are used for training, advertising, simulation, or education and are designed to run on personal computers or video game consoles [6]. Serious games have also been referred to as "games that do not have entertainment, enjoyment, or fun as their primary purpose" [7]. A serious game can more formally be defined as an interactive computer application, with or without a significant hardware component, that i) has a challenging goal, ii) is fun to play and/or engaging, iii) incorporates some concept of scoring, and iv) imparts to the user a skill, knowledge, or attitude that can be applied to the real world[8].

As recent literature reviews [9] on accessibility in games reveal, there are few games available that cater for the needs of people with cognitive disabilities. Most of the limited research is concentrated on rehabilitation and therapy, usually combined with virtual reality techniques, such as the games developed for Nintendo Wii.

The software that Kinect uses also differs from software such as PlayStation II or III because the user is immersed into a true virtual environment, such as a scenic mountain view, and it increases the feeling of being immersed in the activity. Among other benefits, virtual reality allows people with disabilities to increase their interaction with the environment and safely participate in a variety of activities free from the limitations imposed by their disability [10,11]. Virtual reality as a leisure intervention has already produced positive results with children who have cerebral palsy [12], and this holds promise for similar research with adults.

A gesture-based user interface also dispenses with the environmental restrictions that often hamper a touch-based interface; water and other fluids, non-conductive gloves, dirt and germs, etc. However, a first-generation motion implementation such as that utilized by the Nintendo® Wii™ game console system has limitations of its own. An easy-to-lose, breakable, in-hand controller is required to implement the scheme. Additionally, the interface between the controller and the system, usually implemented via Bluetooth®, ZigBee® or some other RF wireless technology, is (like a touchscreen interface) vulnerable to functional degradation due to environmental EMI.

Instead, consider an image sensor-inclusive design. Vision-based gesture interfaces use the human body as the controller versus a dedicated piece of extra hardware, interpreting hand, arm and other body movements. They are comparatively EMI-immune; all that you need to ensure is sufficient operator-to-equipment distance along with adequate ambient lighting[5].

- *Tactile interfaces: Serious games for m-health in iOS/Android*

In this sub-section some examples of serious games developed for different operating systems are described.

— *MaziMazorco [13]*

It is an interactive tool for Apple devices, which, through games and activities, teaches young people with Down's syndrome to live together with the celiac disease.

With the name of MaziMazorco, the application is framed within the project "Aliméntate sin Gluten" ("Feed without Gluten"), a ground breaking program that allows young and adult people with Down's syndrome, as well as their families and professionals to what it means to be celiac, and the guidelines for a healthy diet and good nutrition habits.

The application is free, and it has been developed for iPad, iPhone (3GS Onwards) and iPod Touch (3GS Onwards).

— *My health, my choice, my responsibility [14]*

My Health, My Choice, My Responsibility is a self-paced learning application designed by AbleLink Technologies for a personalised-pace learning of issues that are necessary to maintain a healthy life style. This program is designed to be used directly by users with special needs for the monitoring of a healthy life in a self-paced way, or as part of a learning activity in group, led by an instructor.

— *Kindergarten.com [15]*

Set of applications addressed to young children who use techniques based on the ABA (Applied Behavioral Analysis) principles, and deal with different thematic. It has been proven that the ABA analysis is effective in the learning of children with a typical development, and children with special needs, such as autism, Down's syndrome, dyslexia, speech or language problems.

The applications deal with different subject matters, but they are based on a similar functioning, with real and clear images.

It is also available for iPhone and iPod Touch.
Examples:

- ABA Problem Solving Game – Which Go Together? It works the language and expression acquisition, by means of the problem solving and association

- ABA Problem Solving Game – Healthy Habits? Assisted aid for the learning of good habits in young children through questions and real and clear images to choose from.

- ABA Flash Cards – Food. This application includes big and images of different foods, to help the user to acquire a better vocabulary and expressions dealing with this thematic.

— *Food for kids [16]*

Created by Ventura Educational Systems, this application is intended to young people, with the aim them to learn the different nutrients the foods have, and how these contribute to a good health.

By means of the different activities the application contains, issues such as macronutrients, micronutrients, proteins, fats, vitamins, minerals… as well as information about 46 usual foods are covered. It is not specifically addressed to people with ID.

Review of assistive robotics

The concept of Social Assistive Robotics was first introduced by FeilSeifer D. and Mataric M.J. [17] by a combination of the already existing assistive robotics (AR) and the concept of socially interactive robotics (SIR) introduced by Fong [18].

As they regard, the AR sector was too vaguely defined and did not cover the robots that assisted people without contact interaction. Fong, on the other hand, outlines a new term, SIR, to describe the robots whose main task is to interact with humans or other robots. However, there was a gap between those two concepts just in their intersection of them: AR aided humans providing and helping with the necessary physical therapies while SIR was meant to cover the robots whose goal was to interact for the sake of interaction itself. Thus, Feil-Seifer and Mataric coined the term SAR to define the robots that assisted humans through social interaction instead physical treatments. From that moment on, AR, SIR and SAR have followed separated ways, always towards different objectives.

Assistive Robotics have focused historically on the task of aiding people providing physical assistance [19, 20] disregarding any kind of interaction and focusing only in the practical purpose of the device. Some of the most important branches of this field are the development of intelligent wheelchairs [**Error! Reference source not found.**] assisting the elderly in various ways [22], helping the visual impaired [23, 24], different ways of mobility aid [25, 26], and rehabilitation [26, 28, 29].

On the other hand, Socially Interactive Robots have advanced towards a more purely exploratory research in order to acquire knowledge about social and emotional human expressions and how to adapt them to artificial intelligence. More specifically, studies in SIR have focused on explore human-robot interaction (HRI) as a way to establish a theoretical basis for further research in other fields, such as SAR.

Originally, studies in SIR had no point but to get psychological and behavioral results of immediate interaction between a human and a robot. Thus, they were designed for short-term HRI. A cornerstone of the early investigation in HRI is Breazeal's doctoral dissertation [30] and subsequent book where she defines a sociable robot as the one "capable of engaging humans in natural social exchanges". In this work, Breazaldevelopes Kismet, an socially interactive robot to explore the basic HRI by making questions and responding to emotional behaviors. However, even when this work yielded some of the earliest and most important results on the HRI field, Kismet was developed for short-term interaction, carried out for the sake of interaction itself, a research followed by other important studies as the previously mentioned Fong's survey[31] and the development and subsequent studies of Mitsubishi's Mel, the robotic penguin [32].

This short-term HRI research allowed the establishment of a theoretical basis in HRI. However, as research on this field advanced, it tended to focus more on real applications of such interaction. A good example of this change is Kidd's doctoral thesis [32], in which he takes as a starting point the results of Breazeal's investigation and carries out a research in long-term human robot interaction, which is applied in the design of the weight-loss robotic coach, Autom. This work depicts the turning point from pure interaction, SIR, to actual robotic assistance useful in everyday life, SAR.

Evaluation Techniques

This section outlines objective valuation techniques such as biofeedback and analytics, so as to evaluate and adequate user interfaces and systems to final users' needs.

Biofeedback

Biofeedback is an objective junction of techniques that could be used in objective evaluation. Figure 1 shows the techniques available under the biofeedback term.

Fig-1: Biofeedback techniques

These techniques are classified according to biofeedback methods, measurements, sensors and body areas in which these signals are recorded. This paper will address two specific techniques for used in objective evaluation and adaptation of user interfaces: Electroencephalography and gaze interaction.

Electroencephalography

EEG signals are measurement of the changes in the synaptic activity of the cortex. This is measured by means of magnetic activity generated by neurons and measurable by the use of electromyography systems with electrodes placed over the scalp [33].

EEG signals provide information about health, emotions and behaviours of people. These signals are of great interest for researchers nowadays, especially in the definition of clinical problems such as[34]:

a) Alertness monitoring, coma, cerebral death.
b) Damage areas after cardiovascular illnesses or tumors.
c) Monitoring of cognitive activities.
d) Biofeedback situations.
e) Control anesthesia levels.
f) Research epilepsy and its origin in the brain.
g) Research mental disorders.

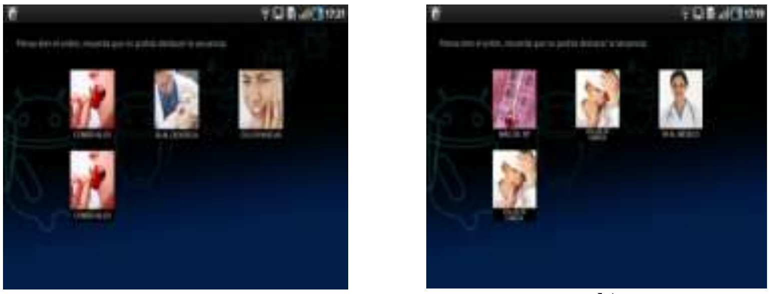
Gaze interaction

Gaze interaction methods are the technologies involved in the monitoring and tracking users' gaze on a particular scene or image. This technology keeps a log of user eye-interaction with the system, that is, which are the areas in which the user focuses his attention and for how long does it remain focused[35].

These systems can be divided into invasive and non-invasive [36].

Eye tracking systems can be also characterized in terms of the methodology used to measure ocular movements:

a) Electrooculogram (EOG): These systems track voltage variation taking place during angular eye movements. The EOG obtenciónn is performed by placing anperbiocular silver - silver chloride electrode system and a bioelectrical driving gel as electrolyte in the electrode interface – skin.
b) Video-oculography (VOG) and Photo-oculography (POG): Non-invasive. They are based on infrared light and cameras equipped with optical sensors. This systems use the reflection in the center of the pupil to determine eye direction through the use of infrared lights. These systems need also image analysis software to determine coordinates in the screen and the pupil size [37].
c) Systems based on contact lenses: Invasive. These devices are the most accurate systems because they are in direct contact with the eye. They employ special lens systems consisting of two single spherical surfaces that fit over the cornea and sclera.



a) b)

Fig-2: Game Interfaces for Healthy Lifestyle

Figure 2 shows a system composed of a set of Serious Games oriented to first aid education: what to do in certain situations, basic knowledge about health, medical specialties ... all employing the use of new technologies such as the Android operating system implemented on mobile phones or tablets.

Microsoft Imagine Cup – USA [38] has used the United Nations Millennium Goals [39] as a basis for competition. An example of a finalist Team (2011 and 2012 Zune category) that represents Edutainment approach is Team Mintrus from the University of Louisville and Columbia College Chicago. Their game, Pandemic, is a tower defense game that acts as a conduit in the education and prevention of AIDS. Players of Pandemic are submerged into the human body, where they assume the role of the immune system in a battle against AIDS. Technologies used are Windows Phone 7 and Microsoft XNA.

Another example from 2011 software category that falls into the therapeutic category is Machine Head from the University of Arkansas at Little Rock, University of Central Arkansas. This project provides an assistive technology that helps children with learning disabilities by converting any source of text to a facial animation display that narrates the text. It also uses Windows 7, Windows Phone 7, Internet Explorer, and Microsoft Visual Studio.

TABLE-I: EXAMPLES OF GAMES FOR VARIOUS OBJECTIVES

Game Objectives	**Example**
Healthy life style	*FIRCA*- Serious Game based on First Aid Education for individuals with Autism Spectrum Disorder (ASD) using Android Mobile Devices [40]
Diagnosis	Using games to assess oesophageal voice [41]
Therapy/Rehab	*Machine Head* from - helps children with learning disabilities by converting any source of text to a narration with a facial animation.
Entertainment	Computer Game to learn and enhance speech problems for Children with Autism [42]
Edutainment	*Pandemic* by Team Mintrus – AIDS education on Microsoft Phone 7.

Figure 2 shows how the tool is training the patient for saying "a" vowel as a game. During this process the software is calculating some acoustic parameters which are important for the diagnosis and the study of the evolution.

Fig-3: Example of an Acoustic Diagnostic Game

Game Styles and Interfaces

The ability of game designers to produce health related games was initially limited by the price and availability of interfaces. This is no longer an impediment as many options are now available and limitations are only based on innovative ideas, analysis of accuracy and effectiveness and user interface design.

Figure 3 is a real example of tool-game designed for patients with larynx cancer in order to study the evolution of their process. If the red line is out of the green area, the patient should speak with his/her therapist.

Fig-4: Interface of a Serious Game for Diagnosis

Prior to expanding on sensors and interfaces, it may be best to clarify that existing hardware platforms (or devices) span a wide range to include:

- Workstations/consoles,
- Laptops and Netbooks,
- Mobile phones, and
- Tablets

This diversity when we include the operating systems provides a challenge for those who want to develop across platforms. However, the availability of sensors and user interfaces for some of these devices will make them more appropriate for some applications. Interfaces include a) Built-in Sensors such GPS and accelerometers, b) External Sensors such heart monitors and pedometers, c) Cameras, d) Different Human Computer Interface (HCI) devices such as touch keyboards, buttons/icons, stylus, Speech and keyboard. In addition to these, there are more complex approaches that would include image recognition for gesture and emotions using one or multiple cameras. Table II summarizes some examples of how to best benefit from such interfaces based on the game objectives.

TABLE-II:EXAMPLES OF APPLICABLE INTERFACES FOR DIFFERENT GAME OBJECTIVES

Objectives / Interfaces	Life Style	Diagnosis	Therapy	Entertainment
Sensors	Pedometer	EEG, ECG	Camera	Accelerometer
Devices	Mobile	Workstation	Tablet	All
HCI….	Speech	Keyboard	Emotion Recognition	Touch Screen

Application and Prototypes

Figure scheme 5 represents the global architecture of the proposed framework games including both local and cloud services

Fig-5: Frame Work Scheme

This section outlines relevant projects carried out in Deustotech-Life Research Unit in Bilbao, Spain and in the City for Scientific Research, Informatics Institute in Egypt. One of the expertise areas of these research centers is the use of computer games for health and therapy. Relevant projects are outlined in this section.

Serious Games for Health using gaming devices

This section presents some real examples of computer games developed with different techniques and aimed at different final users (elderly or children).

Kinect

The developed prototype uses Microsoft's Kinect motion sensor with an integrated database and video instruction. The game has been designed in collaboration with a retirement home and consists of three different levels in which the user should recognize various objects appearing on the screen by moving the arms, in order not to let the objects fall, promoting this way both the mobility of the user during the training and the cognitive process.

On the one hand, the computer game allows to specify the typology of the user; with or without any movement in their legs (use of the wheelchair), and to give the player the option to play standing or sitting.

The main screen (see Figure 6) is in next figure and the user can choose:

- Configuration
- Play
- Finish

Fig-6: Game for the elderly using Kinect- Main Screen

On the other hand, users may present movement problems in either arm (even absence of absolute movement in either of the two members), thus being the game configured in such a way that the user can choose if it wished to play with the left arm, right arm or both.

In order to take the physical limitations of the users into account, a set of configuration options have been designed to make the game easier to play, such as the option of changing the angle of the camera (allowing the user to tilt the device up or down to get a better image or more complete view of the player) only moving one arm up and down, or the choice of a game mode: use the left hand, the right hand, or both.

Some control parameters have been established such as:

- The speed of the objects appearing on the screen
- The quantity or the path they follow, in order to do different movements with the arms.
-

Fig-7: Game for the elderly using Kinect – Level 1

Every level has duration of 30 seconds each to avoid fatigue in training.

- Level 1: the objects (cupcakes and bottles of wine can be seen in Figure 7) shall follow a vertical path.

- Level 2: the number of these objects increases
- Level 3: the objects follow a horizontal path.

Once all the levels are completed, the user shall reach a piece of cake, to achieve as a final reward a whole cake after finishing the three levels.

At the end of the game a score is shown as in figure below with some parameters:

- Needed time
- Number of wined(gained) bottles of wine
- Number of wined (gained) pieces of cakes

The personalized menu allows therapists to adjust the movements according to the conditions of the individual user, and provides them with greater flexibility to adjust the training program according to the individual needs of users.

WiiMote

The game developed hereby is based in a PC software controlled by a wiimote. This games includes 3 scenarios:

- At home
- At school
- In town

At the beginning of the game, the photo of the user is taken with a webcam and, from that moment on, this will be the face of the main character in the game (see Figure 8) so that the user feels more identified with the situation.

Fig-8: Screen display of the game's main character representing the child user

The design was made in a scalable and modular fashion, in such a way that it can easily be amplified and modified, even by non-specialists.

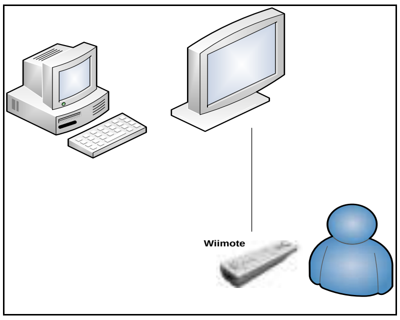


Fig-9: Interaction with the Wiimote

The Wiimote (the interaction can be seen in figure 9) has 11 programmable keys, movement sensors, Infrared and Bluetooth for communication, which in our case is with a PC (using C# programming language) as the human interface device (HID). Within the context concerning us, that of ADDH children, the 11 keys are not used, but just the larger ones, which are easier to use and also intuitive; the functions of the other keys will be deactivated.

Three levels, which the children will have to complete, have been developed for each scenario. Such abilities/skills as responsibility, confidence or Independence are worked on at each level.

In figure 10, the activities diagram for one of the options at the elementary level can be observed: the "asking for help" option is in operation here. Given that this is the elementary level and that the users have to get used to the game and the Wiimote interaction, the number of options available to the user is quite limited.

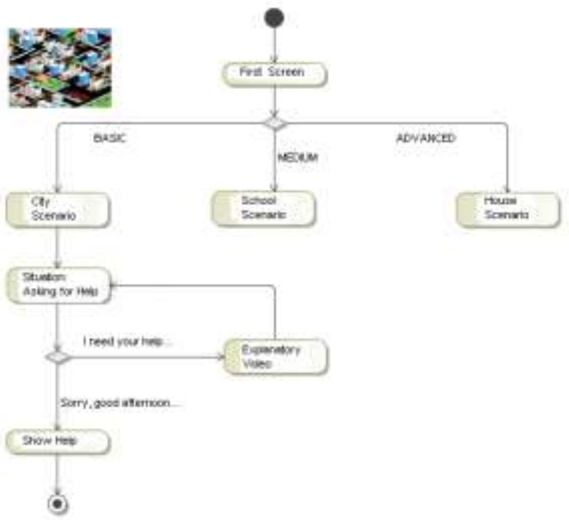


Fig-10: Activity Diagram

At the most advanced level, the user is faced with situations closer to reality, bringing together all the skills previously focused on at the elementary and intermediate levels. There are multiple options available for resolving each situation in all cases.

The user must always know if the chosen option is correct and why, for which purpose explanatory videos are employed. The user receives positive awards for work well done (medals, for example), and the progress made is logged. The instructors will revise the results in order to assess the validity of this new treatment.

An example of image coming from a scenario is Figure 11:

Fig-11: Example of the town scenario forming part of the third learning level

Tactile interfaces: Serious games for mhealth

Intellectual disabled people usually have problems with daily habits such as: healthy food election, hygiene maintenance or differentiation of the coins. Due to those reasons, some serious games related to these fields have been developed and it can be seen in Figure 12 [43].

Fig-12: Money Games Prototype

Augmented Reality game based on the Tangram puzzle

This system is based on the traditional Chinese game Tangram. It has been specially designed for producing a transient increase in psychomotor activity for the elderly and its classic version is widely used in stimulation therapies.

This system has been implemented with augmented reality techniques. On the one hand these methods are used to provide the user with an interaction with both physical and virtual pieces. This helps on the improvement of their cognitive faculties. On the other hand this technology is employed to the exhaustive monitoring of user movements over the pieces (see Figure 13).

Fig-13: Tangram Game

This system leads to the development of a new prototype able to perform autonomous therapies with the tangram. It also generates an objective report for the therapist.

The obtained results suppose a higher control in daily assisted-therapies. This is a clear contribution to obtain a satisfactory relationship between the user and the therapist through the implementation of new relational alternatives.

The tests performed using the prototype have shown the viability of the system to enhance the cognitive capacities of the elderly. It has been tested with a user group aged between 65 and 78 years. The reports generated by the system have supposed an innovation in user therapies. These records provide an objective measurement of cognitive progresses in users.

Assistive robotics

The Lego robot has been chosen to develop applications for children with intellectual disability and autism, in order to work social habits in hygiene and autonomy when doing the grocery shopping. In particular, a series of applications for IPod have been made as a reply to the only software version made for IPad.

Figures 14 and 15 show an example of a game session with the robot.

Fig-14: Preliminary tests with robotics in Deustotech-Life Lab

Fig-15: Preliminary tests with robotics in Deustotech-Life Lab

The game starts offering the following options, according to the figure 16:

- Clothing
- Money
- Hygiene
- Food

Fig-16: User interface example in robotics game

The type of images used here is very simple is simple and clear. For instance, the following image is the one used to work the oral hygiene practices. The user will see the image of a child with darkened teeth, and, as the toothbrush moves through, with the toothpaste over each zone for at least 5 seconds the teeth start to brighten, symbolising that they start to clean out.

Fig-17: User interface example in robotics game

The experience in the tests carried out with this type of games for the specified users' profile (children with intellectual disability or autism) proves the accessibility of the technology and its attractive use to work the interesting aspects that are most relevant in each case.

Social and Cultural Games

A prototype of walkthrough application in Pyramid Plateau is built to allow tourists to freely walkthrough the virtual reality model of pyramid and sphinx area. It also allows the users to fly through and interact with the objects. The development of this task involves three steps, namely, modeling of the pyramids, Sphinx, and the surrounding terrain, texture mapping and rendering, and interactive virtual environment development. The modeling step is implemented in 3D STUDIO MAX 9.0 software [44]. Use has been made of the data collected from the terrestrial and aerial scanning. Aerial scans provide othophotos, digital elevation maps for terrain and geometric modeling. Additionally, high resolution digital photographs and meshed triangulated surfaces from terrestrial scanning data have been used for texture mapping. Model detail was balanced with texture detail, which means that the higher the detail in the meshed surfaces, the lower the detail in the texture and vice versa. This provides an acceptable real-time rendering performance while maintaining good visual quality. The virtual environment development is implemented using Quest3D [46] a highly sophisticated software for creation of virtual environments. Quest 3D allows for a relatively short development time and cost efficient development because the framework for displaying real time graphics is already laid out. All of the coding in Quest 3D is done using Visual Programming, the code is displayed using linked blocks that form are hierarchical structures This provides an intuitive working environment.

Texture maps can be compressed using the DDS format, which is the native format used in Quest 3D. DDS images contain mipmaps used in the rendering process. Although mipmaps can increase the image file size slightly, they allow for higher rendering speed because they do not need to be calculated at runtime. Quest 3D also supports automatic and manual Level of detail (LOD) meshes. LOD refers to the process of describing a complex 3D model using different representations, from very detailed to extremely simple ones. Automatic LOD was used on secondary 3D objects that are never close to the camera, whereas manual LOD was used on all primary models. Additionally, Quest3D software has effective communication with 3ds max application, and supports many options for output format. The developed virtual environment model features an interactive user interface. The user interface is a keyboard/mouse interface that can function even if one of the two input devices is not available. The option of 3D vision is also included and requires 3d stereo glasses. The Pyramid plateau prototype allows game designers to create scenarios inspired from Egypt's history (see Figure 18).

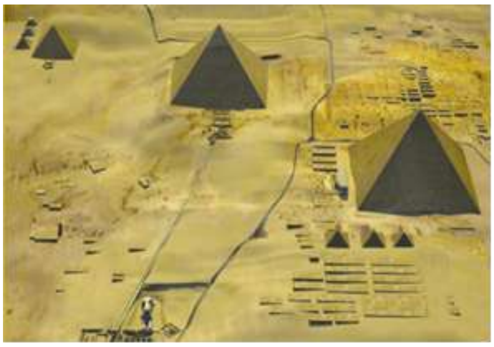


Fig-18: Pyramid plateau prototype

Evaluation Techniques

The way to evaluate the applications of the kind of "serious games" can appeal to different techniques, concerning the examples described in this article; the techniques used were as follows:

- Evaluation Surveys
- Objective Evaluation using biofeedback

Let us start with an example what would each one consist of.

Evaluation surveys

The fulfilment of evaluation surveys is a classic method to obtain feedback about the application. To do so, it would be necessary to identify the system actors who should be asked.

In order to avoid generalisations, let us see a particular case of evaluation of the Kinect game for healthy life in older people, which we have spoken about in this article.

On this occasion two different questionnaires have been prepared:

- For the users

TABLE-II: QUESTIONNAIRE FOR ELDERLY USERS

ELDERLY QUESTIONNAIRE (YES/NO)

1. Did you enjoy the game?
2. Did you have fun?
3. Would you play more?
4. Did you find the game comlicated?
5. Did You feel tired or make an uncomfortable movement?
6. Did you enjoy the music?
7. Did you enjoy the landscapes/game background?
8. Would you like other type of objects to fall, except but cakes/bottles?
9. Did you know/have you ever play with the Kinect sensor?
10. ¿Do you use a computer at home/work?

SUGGESTIONS:

- What did you like the most/the least?
- What would you add/Change in the game?

- For the therapists

TABLE-II: THERAPISTS QUESTIONNAIRE

SPECIALIST QUESTIONNAIRE:

1. Could the users utilize the application frequently?
2. Is the Complexity level appropriate?
3. Would they need help to play?
4. Were the users comfortable playing?
5. Is the dynamic of the game understood?
6. Are the explanations and conclusions appropriate?
7. Is the type size appropriate?
8. Isthedesignappropriate?
9. Does the game become slow, hard?

SUGGESTIONS:

During the project pilotage 3 tests were taken, and, in all of them, the surveys were delivered to therapists and users. New modifications have been incorporated in the software application, a result of the analysis of the data. Such modifications mainly affected to:

- The colors used
- The time between the objects appearing on the screen, in such a way that they may be adapted to users with more or less abilities.
- The position of the user, sitting and standing, in order the users to be able to achieve the 100% of the objects during the game execution.

Once the three pilots made, the final result consisted in providing a higher degree of satisfaction, a result of their participation in the specification process (prior to starting the development), and in the evaluation process (during the three pilots made).

Objective evaluation using biofeedback

Objective evaluation can be done through the use and analysis of biofeedback techniques. This paper will focuses on the use of biofeedback based on EEG signals analysis, also known as neurofeedback; and eye gaze interaction analysis.

Biofeedback techniques are used for evaluation, regulation and/or accessibility purposes.

Neurofeebback training is based on the regulation of specific features inside the electrical brain activity. This is done by sending immediate feedback and positive reinforcement, usually visual or auditory, and could be used to adapt interfaces and systems to user needs [46. In recent decades there have been many studies on the feasibility of the use of neurofeedback as a treatment of several disorders, as it is the case of ADHD [47,48].

The use of neurofeedback for cognitive activity and attention regulation could be of great interest in the field of education to monitor students' progresses and improve educational programs based on each user's needs [49.

EEG biofeedback is a topic of increasing interest among the scientific community, and it is being used in the evaluation of attention span [50], in the improvement of executive functions and behavioral training [51], its long-term effects [52], its use in health related problems, illnesses and disorders [53-55] and its efficacy [56,57] among others. The ability to determine changes in bioelectric signals of brain function activities and the detection of cognitive non-standard behaviors through the comparison of several users and controls are a step forward in the study of these problems.

Eye gaze interaction technologies could be used for different purposes. One of these is the objective evaluation of user interface. Across the literature there are several references to usability studies focused on assessing the user experience in software developments through the use of eye tracking devices for measure user interaction related to legibility, icons [58, 59].

Eye tracking devices have been also used in search engines and to assess the impact of online publicity and magazines in users [60].

Gaze interaction systems have also been used as input devices, so as to promote interaction and accessibility in electronic systems such as videogames. This allows designers and developers to create new user experience and promote games across people with disabilities. This system requires of gaze movements to control games and software, providing eye tracking systems with joystick functionalities [61].

The combination of any of these biofeedback techniques with Serious Games for Health could provide the ideal framework for complementary therapies. This mixture supplies the professionals with an adaptative and accessible tool that could increase motivation and engagement among children and adults.

CONCLUSIONS

Benefits and Challenges of the proposed approach need to be considered and evaluated. Some of these are apparent from the framework and others will require experimentation at various levels of implementation and deployment.

Benefits of Integration

Personalization based on patient profile and data collected from various therapies and diagnostic tests is one of the immediate benefits. This allows the creation of adaptive environments based on changes in user/patient conditions. Also, a modular design allows easy upgrades and redesign based on new discoveries and technological advances. The unified core serves various disease and therapies simultaneously and reduces duplication contributing to lower cost and better data integrity.

Challenges of Integration

Such an integrated system has an immediate challenge in requiring continuous communications among its various modules. This can be alleviated by using some asynchronous modules when feasible.

Other major challenges that the distributed nature of the system bring about is security and authentication of users and their approved access roles. This can be addressed by creating multiple user interfaces/ viewpoints and perspectives which is also a good approach from a usability view.

Eventually challenges for storage and real time interpretation of an infinitely growing data repository will have to be the ultimate challenge. So, from small data used on phones and portable devices with limited storage and computation grows Big Data that is the current challenge facing everyone.

However, the main benefit remains to be that Games can provide an improved lifestyle and a more friendly approach to health diagnostics and therapies when possible.

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Conflicts of Interest

The authors declare no conflicts of interest

Abbreviations

ABA: Applied Behavioural Analysis
EEG: Electroencephalogram
EKG: Electrocardiogram
EOG: Electrooculogram
HCI: Human- Computer Interaction
HID: Human- Interface Device
HRI: Human- Robot Interaction
LOD: Level of Detail
POG: Photo- Oculography
SAR: Socially Assistive Robotics
SIR: Socially Interactive Robotics
VOG: Video- Oculography

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